

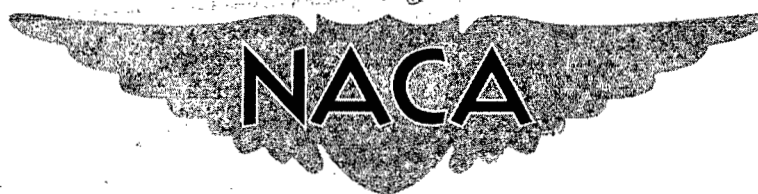
Copy
A 7-4249801

SECURITY INFORMATION

C.2

Copy 44
RM SL53J12

CONFIDENTIAL



RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

WIND-TUNNEL INVESTIGATION OF THE MOTION OF A 1/10-SCALE

MODEL OF THE DOUGLAS XF4D-1 ESCAPE CAPSULE

WHEN JETTISONED BY JET EJECTION

TED NO. NACA DE 359

By Harold S. Johnson

CLASSIFICATION CHANGED

Langley Aeronautical Laboratory
Langley Field, Va.

UNCLASSIFIED

To _____

By authority of *NASA TPA 7* Date *5-29-59*

WB 7-7-59

CLASSIFIED DOCUMENT

This material contains information affecting the National Defense of the United States within the meaning of the espionage laws, Title 18, U.S.C., Secs. 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

0517-1953

CONFIDENTIAL



3 1176 01438 6651

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

WIND-TUNNEL INVESTIGATION OF THE MOTION OF A 1/10-SCALE

MODEL OF THE DOUGLAS XF⁴D-1 ESCAPE CAPSULE

WHEN JETTISONED BY JET EJECTION

TED NO. NACA DE 359

By Harold S. Johnson

SUMMARY

A wind-tunnel investigation was made at low speed to determine the path and motion of a 1/10-scale model of the Douglas XF⁴D-1 escape capsule without the drogue parachute when jettisoned by jet ejection. The investigation included determination of the vertical and horizontal accelerations of the capsule.

The results of the investigation indicated that at 0° angle of attack the capsule initially left the fuselage cleanly and cleared the vertical tail at the two free-stream velocities investigated (180 and 273 ft/sec which correspond, respectively, to full-scale airspeeds of about 570 and 863 ft/sec (389 and 588 mph)). The compressibility effects that would be present for the full-scale conditions were not present in the model tests. The vertical displacement of the capsule center of gravity as the capsule passed over the tail was reduced from about 50 feet (full scale) to about 25 feet when the airplane velocity was increased from 570 to 863 ft/sec (full scale).

INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, a brief investigation of the path and motion of a 1/10-scale dynamic model of the Douglas XF⁴D-1 escape capsule when jettisoned by jet ejection was made in the Langley 300 MPH 7- by 10-foot tunnel. The emergency escape

[REDACTED]

capsule consists of the airplane cockpit which is ejected upward by means of a jato bottle. The capsule is stabilized by fins that are deflected upon release of the capsule. A drogue-type parachute deployed on release of the capsule is used to slow the cockpit down to a speed at which a conventional-type parachute can be used to lower the capsule to earth. A design evaluation of the escape capsule is presented in reference 1. Static wind-tunnel data for the capsule are presented in references 2 to 4.

This paper presents the path and motion of a 1/10-scale dynamic model of the cockpit capsule immediately after jettisoning by jet ejection at speeds corresponding to full-scale-airplane velocities of 0, 570, and 863 ft/sec. The angle of attack of the airplane model was 0° for all tests and the capsule was not equipped with the drogue parachute.

SYMBOLS

a	acceleration of capsule, ft/sec ²
g	acceleration of gravity, 32.17 ft/sec ²
I	moment of inertia, slug-ft ²
R	scale ratio, ratio of any full-scale dimension to corresponding model dimension
s	displacement of capsule center of gravity, ft
T	thrust, lb
t	time, sec
V	free-stream or airplane velocity, ft/sec
v	velocity of capsule, ft/sec
Δv_x	decrease in horizontal velocity, $V - v_x$
W	weight, lb
ρ	mass density of air, slugs/cu ft

Subscripts:

z vertical component
x horizontal component
m model
fs full scale

APPARATUS AND METHOD

A drawing of the 1/10-scale model of the Douglas XF⁴D-1 escape capsule as mounted in the airplane model is shown in figure 1. The geometric characteristics of the cockpit capsule are shown in figure 2. Photographs of the model capsule and airplane as mounted in the Langley 300 MPH 7- by 10-foot tunnel are presented as figure 3. The capsule (shown in figs. 2 and 4) was made of 1/32-inch-thick plastic impregnated Fiberglas, and the rocket was contained within the capsule. The spring-operated magnesium fins were deflected when the rocket blast broke the retaining string (fig. 4(b)). The capsule model was not equipped with the drogue parachute.

The solid-mahogany airplane model was hollowed out to the plan form of the capsule plus about 1/32-inch clearance to a plane about 1/2 inch below the lowest point of the capsule (fig. 2). The volume of the chamber around the capsule was believed to be less than that of a truly scaled prototype. In an attempt to compensate for the small size of this chamber in the model, a $1\frac{3}{8}$ -inch-diameter vent was located in the bottom of the fuselage in line with the rocket thrust axis. Wind-off tests were made with this vent both open and closed. Destruction of the capsule prevented testing at a forward velocity other than zero with the vent sealed.

The capsule reference axis was at an angle of attack of -11° when the airplane was at 0° angle of attack. The capsule was held in the fuselage by a fuse wire which also short-circuited the rocket-firing circuit. When the fuse wire burned through, a solenoid was tripped and the rocket fuse was energized.

The path of the capsule was photographed by a multiple-exposure still camera and by motion-picture cameras. From the pictures of the flights made with the still camera, the path and motion of the cockpit capsule were obtained.

The test free-stream velocities were 180 and 273 ft/sec and the corresponding full-scale airspeeds were 570 and 863 ft/sec (389 and 588 mph), respectively, based on the following relationship (from ref. 5):

$$V_{fs} = \sqrt{R} V_m$$

The compressibility effects that would be present for the full-scale conditions are not present in the model tests. The model capsule was ballasted with lead weights to approximate dynamic similarity to the full-scale capsule at an altitude of about 11,000 feet ($W_{fs} = 953 \text{ lb} = R^3 W_m \frac{\rho_{fs}}{\rho_m}$, refs. 5 and 6). The full-scale moments of inertia in pitch (283 slug-feet²) and yaw (233 slug-feet²) were scaled to within 2 percent for all tests ($I_{fs} = R^5 I_m \frac{\rho_{fs}}{\rho_m}$). The moment of inertia in roll (31.3 slug-feet²) could not be duplicated and the scaled-model inertia in roll was about 40 percent high.

The constant thrust against time characteristic of the full-scale jato unit could not be duplicated in the model testing ($T_{fs} = R^3 T_m \frac{\rho_{fs}}{\rho_m}$, $t_{fs} = R t_m$), but the average scaled thrust was approximately equal to the full-scale value (9,900 pounds for 0.24 second). A typical model-rocket thrust-time variation, converted to full-scale values, is shown in figure 5. The maximum thrust obtained was about 22,000 pounds (full scale) and the effective duration of thrust was about 0.24 second (full scale).

The photographic data were used to establish the variation of the vertical and horizontal displacements of the capsule center of gravity with time as the capsule moved in the airstream. The relationships used in obtaining the full-scale displacement-time curves were obtained from reference 5 and are as follows:

$$s_{fs} = R s_m$$

$$t_{fs} = \sqrt{R} t_m$$

The first and second differentiation of the displacement-time curves were obtained graphically in the determination of the vertical and horizontal

velocities and accelerations. The graphically determined accelerations are believed to be accurate only within $\pm 2g$.

The angle of attack of the airplane model was 0° for all tests.

RESULTS AND DISCUSSION

The data were not obtained at full-scale values of Reynolds number and Mach number and their probable effects have not been estimated. It is believed, however, that the results give a qualitative indication of the full-scale-capsule behavior without the drogue parachute. Only one ejection was made for each test condition investigated. In the discussion and in the figures, all the data are presented as full-scale values.

Ejection at Zero Airspeed

For the ejection without the fuselage vent, the capsule was moving with appreciable velocity at a height of about 80 feet (limit of travel). The capsule pitched up from the initial -11° attitude to 90° at a height of about 40 feet. Since the height attained was much greater than estimated, the vent was drilled in the fuselage to simulate more nearly the internal volume of the airplane and thereby eliminate the excess buoyancy effect of the rocket blast. With the vent, the capsule attained a maximum height of about 43 feet. This firing was in good agreement with the predicted trajectory of reference 1 for a constant acceleration of $6g$ for 0.3 second. The capsule rotated nose upwards about 1 revolution before maximum vertical displacement was obtained. Velocities and accelerations were not determined for the $V = 0$ firings since only motion-picture records were obtained.

Ejection at $V_{fs} = 570$ Feet Per Second

The capsule left the fuselage cleanly and the height attained at the end of powered flight was about $6\frac{1}{2}$ feet. The capsule passed out of the field of view of the multiple-exposure still camera at a height of about 36 feet before traveling horizontally as far as the tail (figs. 6 and 7). The motion-picture films indicate that the vertical displacement of the capsule center of gravity as the capsule passed over the tail was about 50 feet. The capsule pitched up slowly until a height of about 36 feet was attained and then pitched more rapidly. The capsule rolled about one-fourth of a revolution while rising about 36 feet and thereafter rolled more rapidly. The vertical velocity increased rapidly during the powered portion of the ejection and reached a maximum of about 65 ft/sec

at about the end of the rocket-thrust period (fig. 8). The vertical acceleration reached a maximum of about 15.5g during the rocket-thrust period and was greater than 10g for about 0.12 second (fig. 8). The vertical acceleration became negative about 0.22 second after release. The horizontal acceleration reached a maximum value of about -5g during powered flight.

Ejection at $V_{fs} = 863$ Feet Per Second

The capsule left the fuselage cleanly and the vertical displacement of the capsule center of gravity was about 25 feet as it passed over the vertical tail (figs. 7 and 9). The capsule pitched nose downward about 8° as the capsule left the fuselage and remained at approximately this angle until it reached a height of about 20 feet ($t_{fs} \approx 0.6$ second). The capsule then pitched, rolled, and yawed violently. The fins were blown to a partially deflected position during these attitude changes. The maximum vertical velocity was about 72 ft/sec and occurred at about the end of the rocket-thrust period (fig. 10). The vertical accelerations during the power-on portion of the ejection were very similar to those observed for the capsule at $V_{fs} = 570$ ft/sec (figs. 8 and 10). The vertical decelerations after rocket burnout were greater for $V_{fs} = 863$ ft/sec than for the lower airspeed investigated. The rapid attitude changes after a vertical height of 20 feet was reached are reflected in the acceleration curves. The variation of horizontal acceleration with time was similar to that for the $V_{fs} = 570$ ft/sec flight until the rapid attitude changes occurred.

Because of changes in the aerodynamic characteristics of the capsule, particularly drag, with Mach number, the flight path for full-scale conditions could be considerably different than that obtained from the model tests. The difference between model and full-scale thrust-time characteristics could also result in a change in the flight path of the capsule. The addition of the drogue parachute which is released in a deployment bag upon firing of the rocket could also change the flight-path characteristics.

CONCLUDING REMARKS

A brief wind-tunnel investigation was made to determine the path and motion of a 1/10-scale dynamic model of the Douglas XF4D-1 escape capsule without the drogue parachute when jettisoned by jet ejection at an airplane angle of attack of 0° . The results of the investigation indicated that the capsule initially left the fuselage cleanly and cleared the vertical tail at the two free-stream velocities investigated (180 and 273 ft/sec which correspond, respectively, to full-scale airspeeds of

570 and 863 ft/sec (389 and 588 mph)). The compressibility effects that would be present for the full-scale conditions were not present in the model tests. The vertical displacement of the capsule center of gravity as the capsule passed over the tail was reduced from about 50 feet (full scale) to about 25 feet when the airspeed was increased from about 570 to 863 ft/sec (full scale).

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., September 30, 1953.

Harold S. Johnson

Harold S. Johnson
Aeronautical Research Scientist

Approved:

George F. Van Duzall Jr.
for Thomas A. Harris
Chief of Stability Research Division

ecc

REFERENCES

1. Walpole, H. L.: Full Scale Mockup Study of Ejectable Cockpit. Rep. No. ES-21449, Douglas Aircraft Co., Inc., Apr. 5, 1949.
2. Kasari, E. B., and Muse, T. C.: Low-Speed Wind-Tunnel Tests of an Ejectable Cockpit. Rep. No. ES 21487, Douglas Aircraft Co., Inc., July 29, 1949.
3. Kasari, Elmer B.: High-Speed Wind-Tunnel Tests of an Ejectable Cockpit. Rep. No. ES-15436, Douglas Aircraft Co., Inc., Feb. 27, 1950.
4. Kasari, E. B.: Summary Report on Wind Tunnel Tests of an Ejectable Cockpit at $M = 1.2$. Rep. No. ES-15576, Douglas Aircraft Co., Inc., Nov. 30, 1950.
5. Scherberg, Max, and Rhode, R. V.: Mass Distribution and Performance of Free Flight Models. NACA TN 268, 1927.
6. Neihouse, Anshal I., and Pepoon, Philip W.: Dynamic Similitude Between a Model and a Full-Scale Body for Model Investigation at Full-Scale Mach Number. NACA TN 2062, 1950.

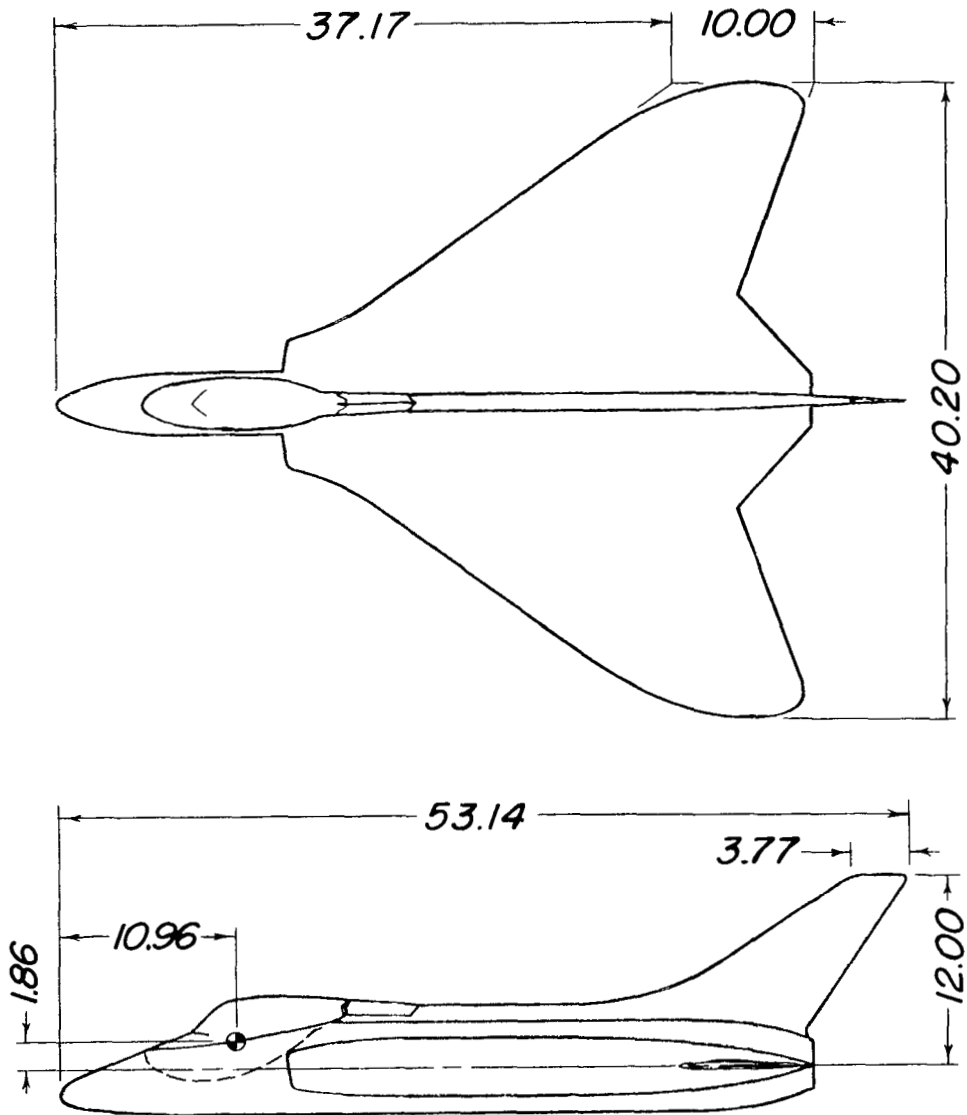


Figure 1.- Drawing of the 1/10-scale model of the Douglas XF4D-1 airplane and escape capsule. (All dimensions are in inches.)

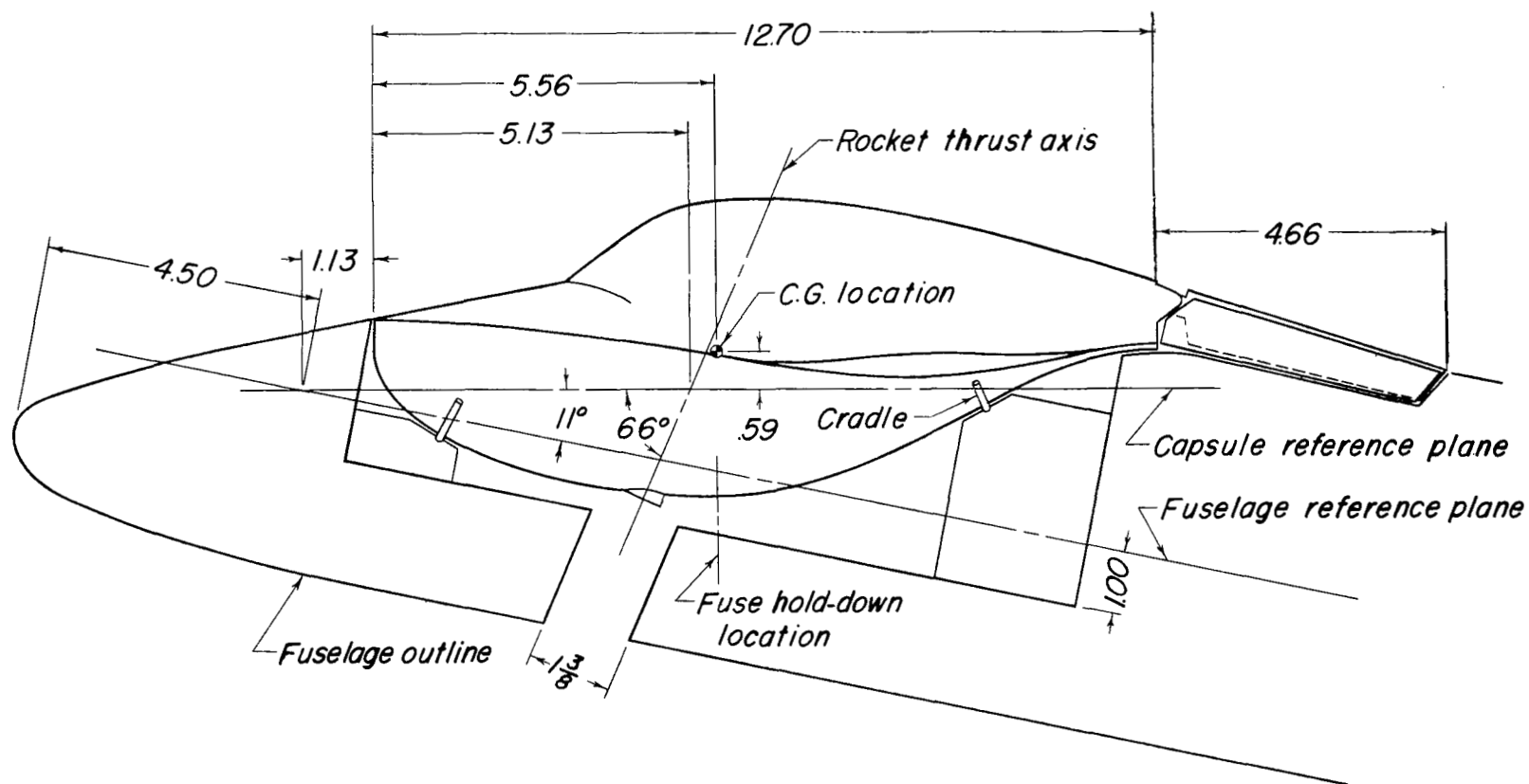
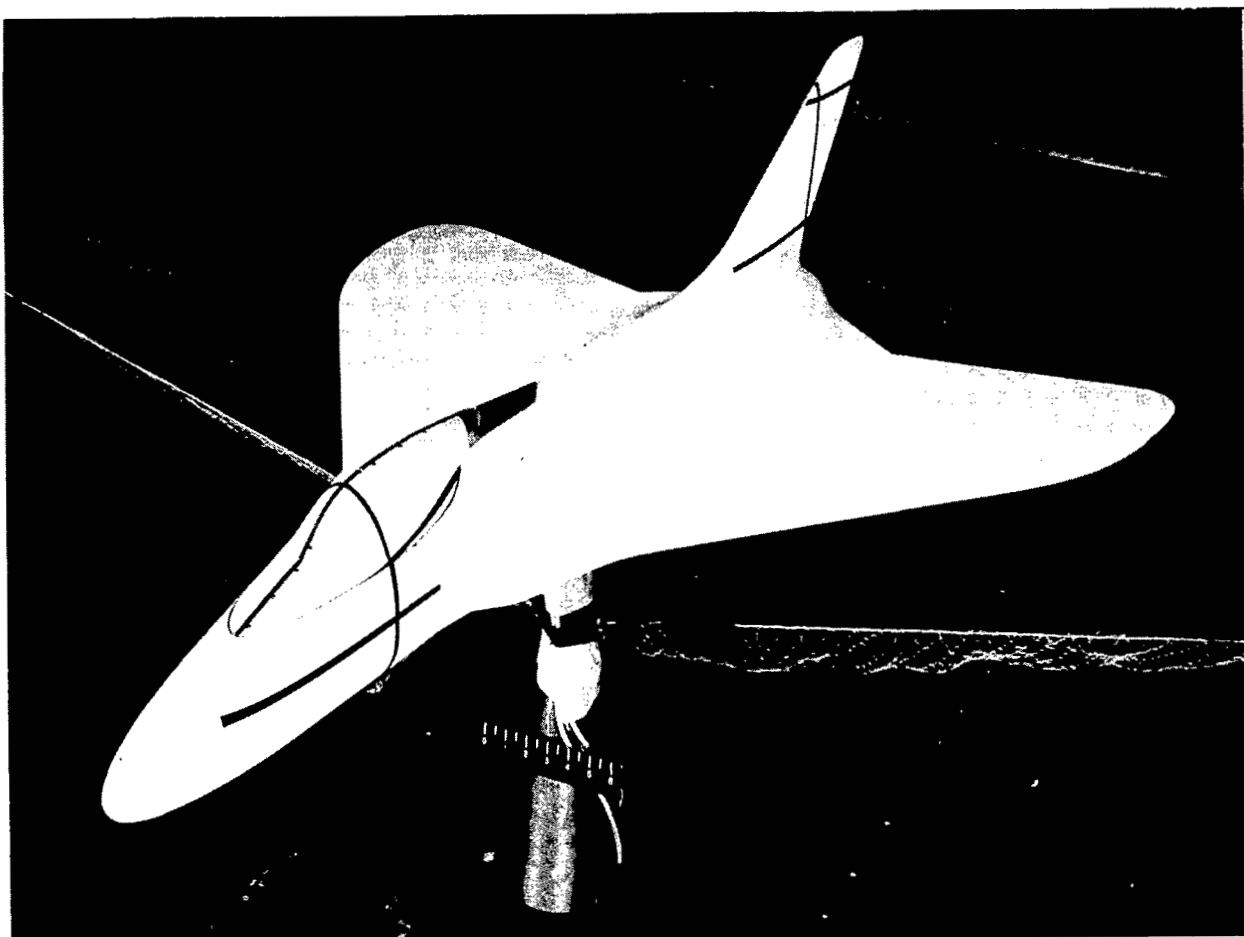


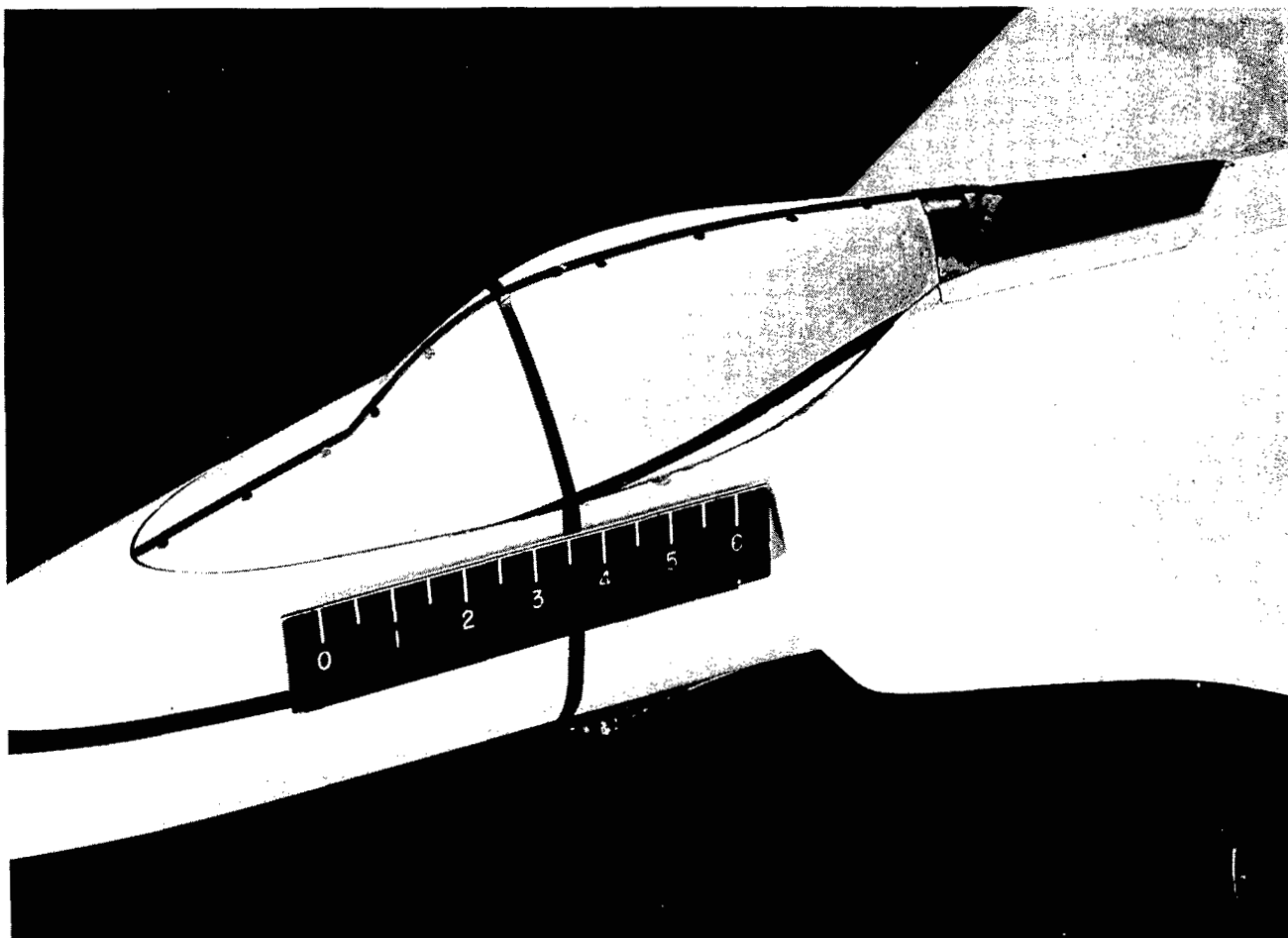
Figure 2.- Geometric characteristics of the 1/10-scale model of the Douglas XF4D-1 escape capsule. (All dimensions are in inches.)



L-74070

(a) Capsule installed in model.

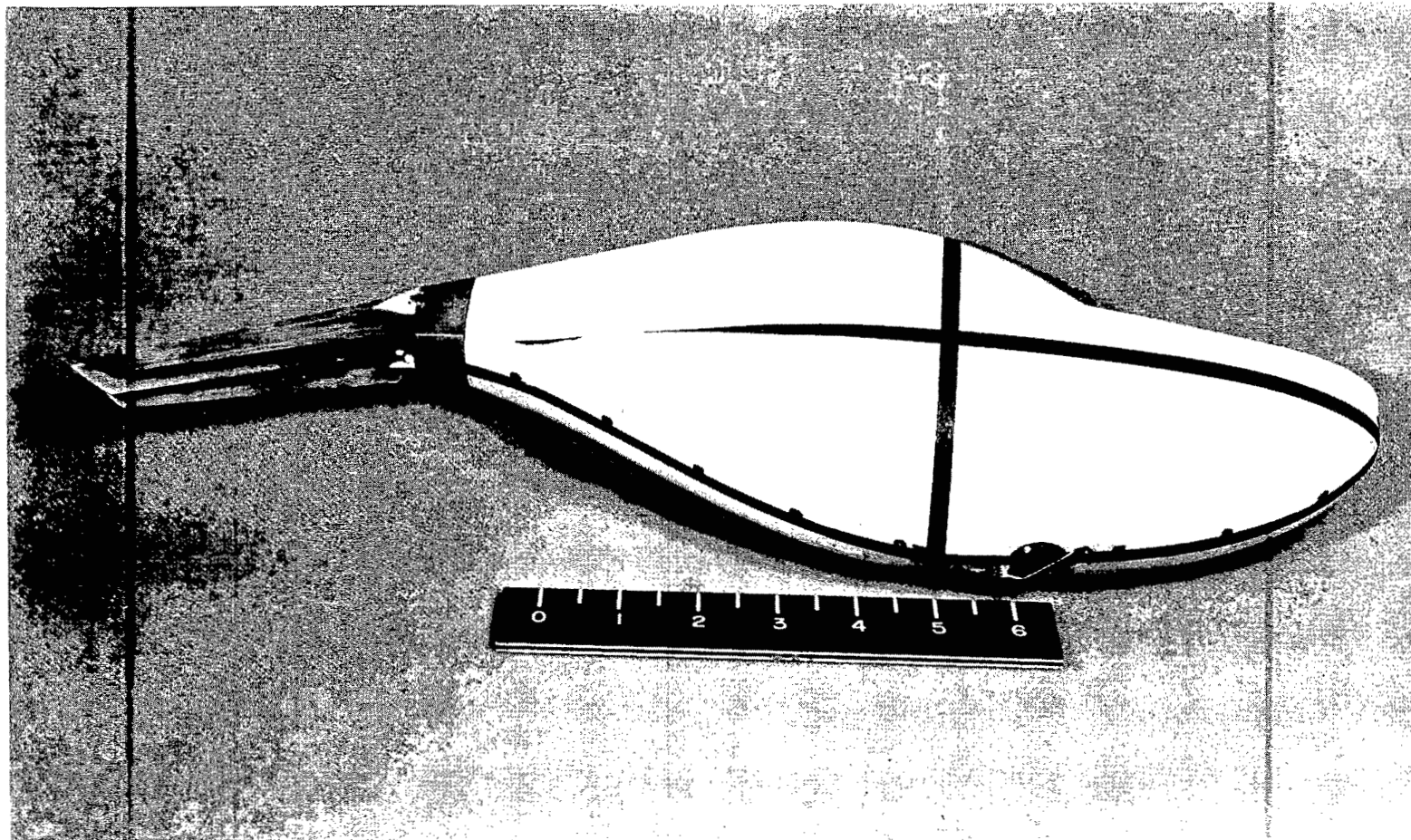
Figure 3.- The 1/10-scale model as mounted in the Langley 300 MPH
7- by 10-foot tunnel.



(b) Closeup view of capsule.

L-74071

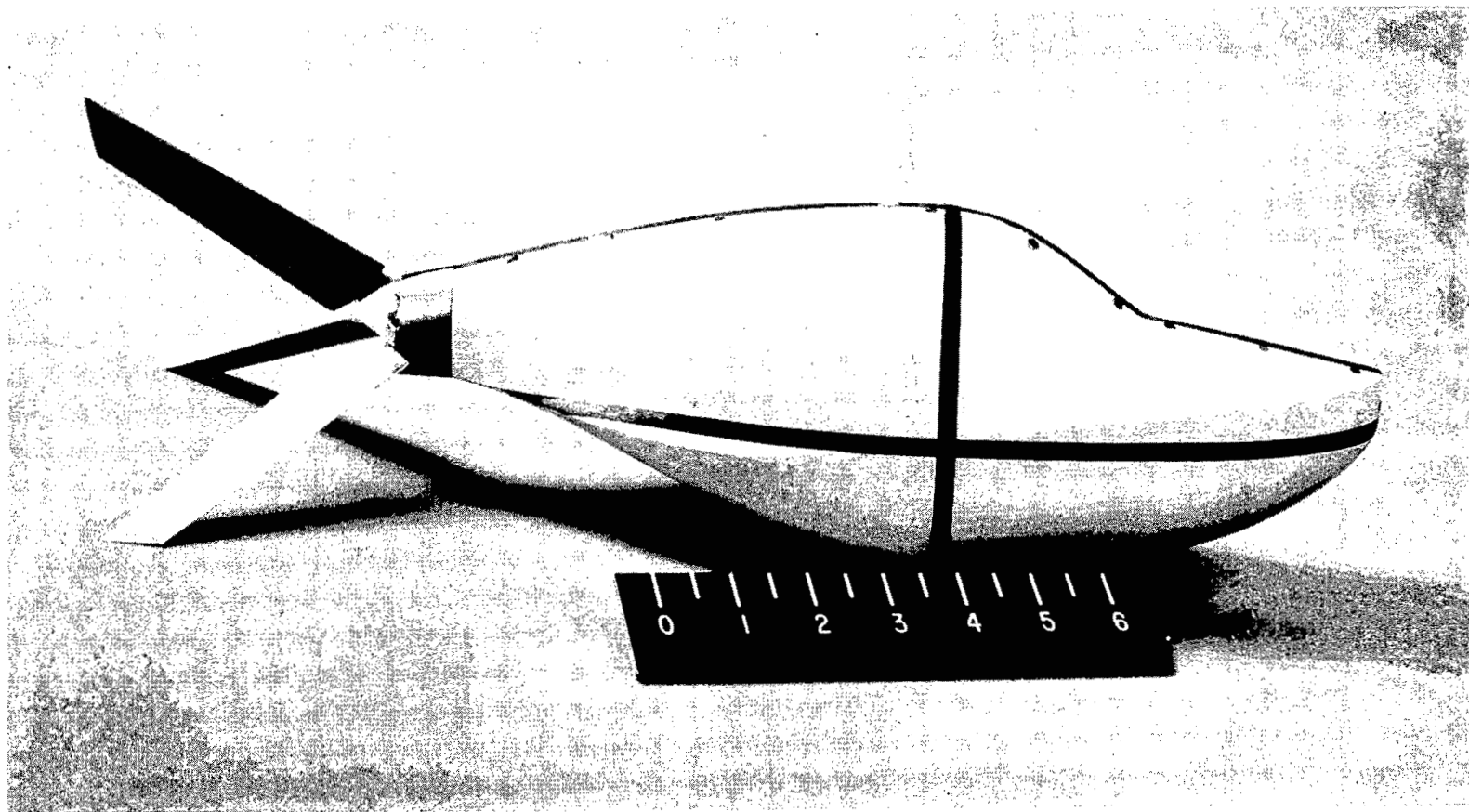
Figure 3.- Concluded.



L-73905

(a) Fins retracted.

Figure 4.- Photographs of the 1/10-scale model of the escape capsule.



(b) Fins deflected.

L-73904

Figure 4.- Concluded.

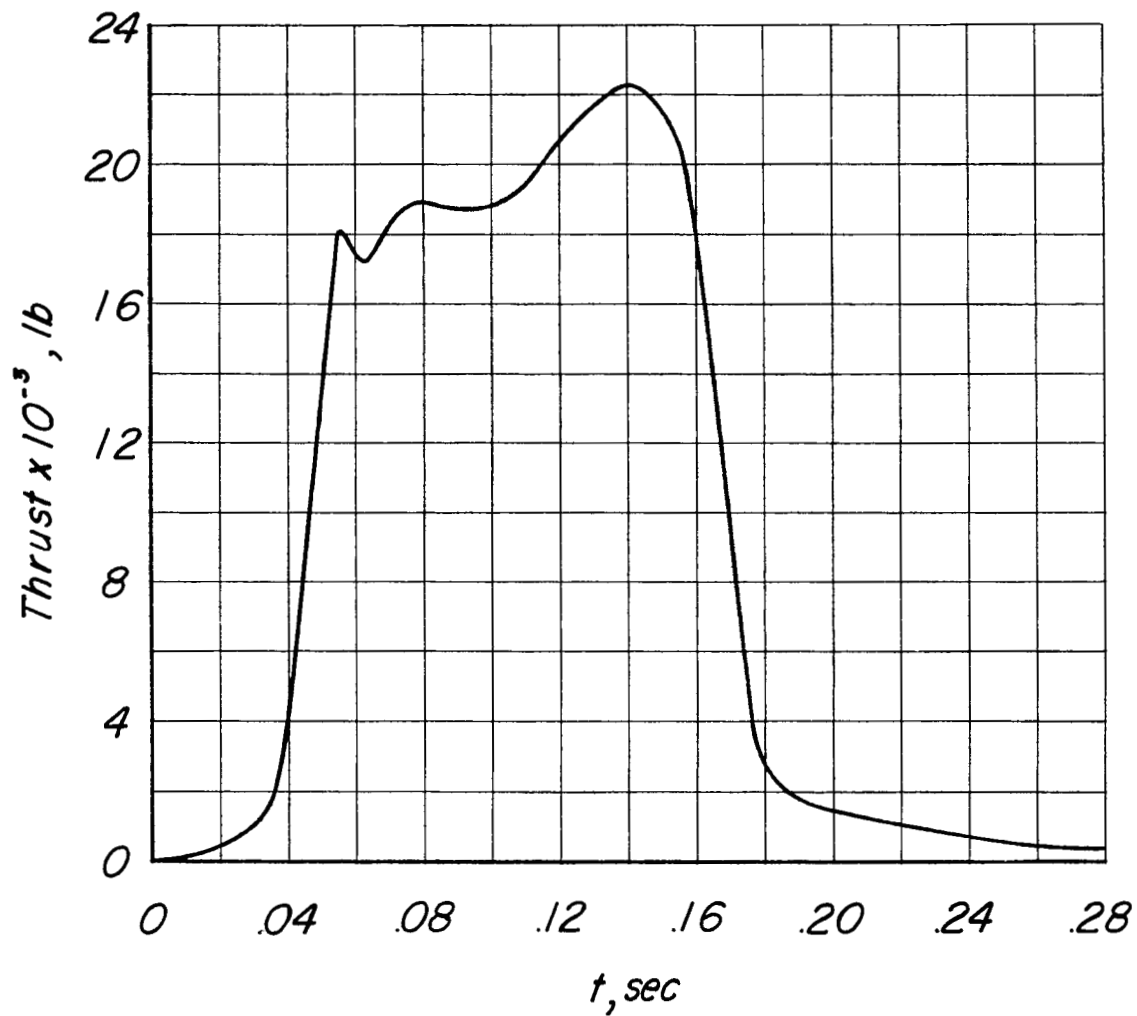
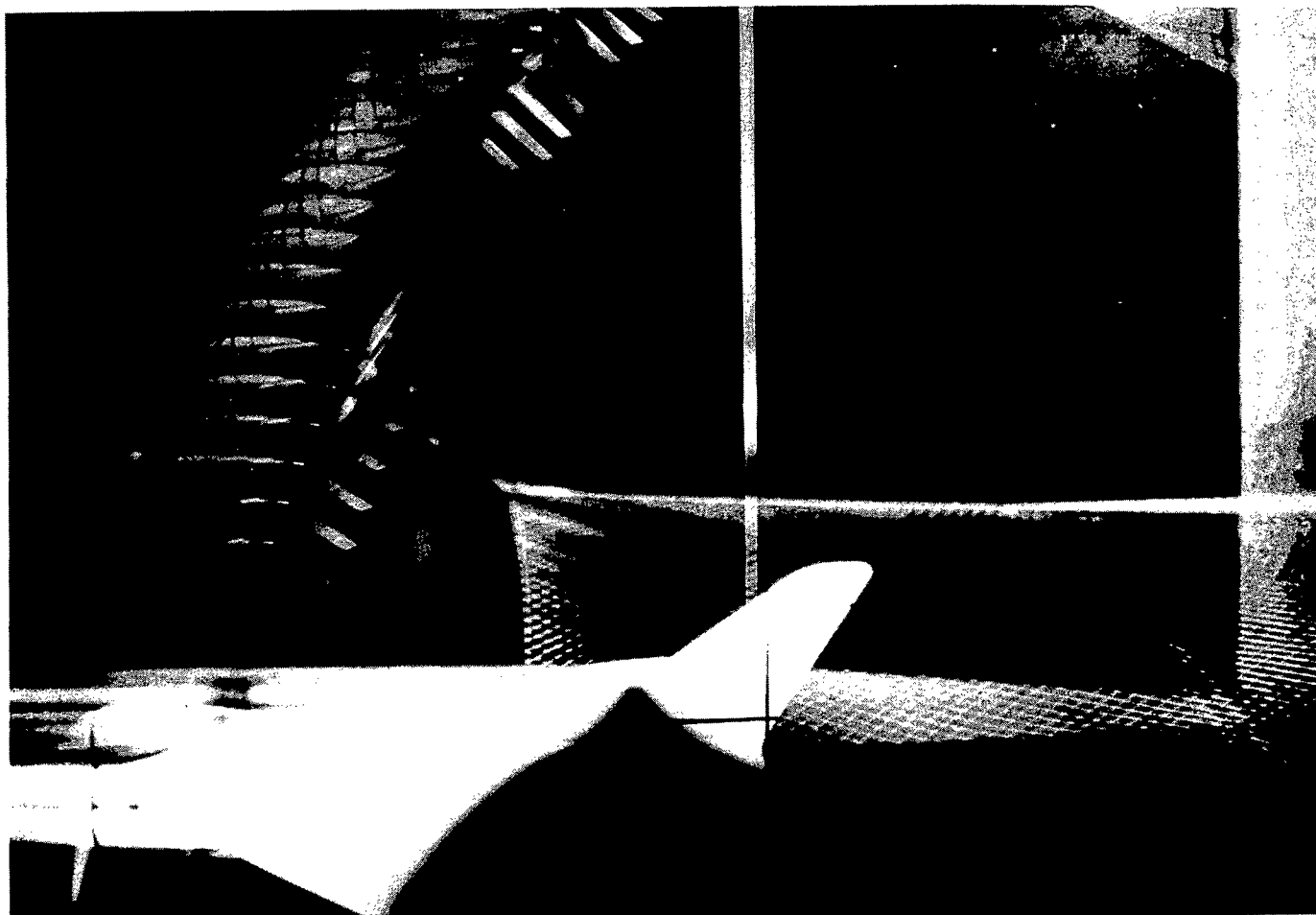


Figure 5.- Typical variation of model rocket thrust with time (converted to full-scale values).



L-74064

Figure 6.- Motion and path of the model escape capsule following ejection.
 $V_{fs} = 570 \text{ ft/sec (389 mph)}$.

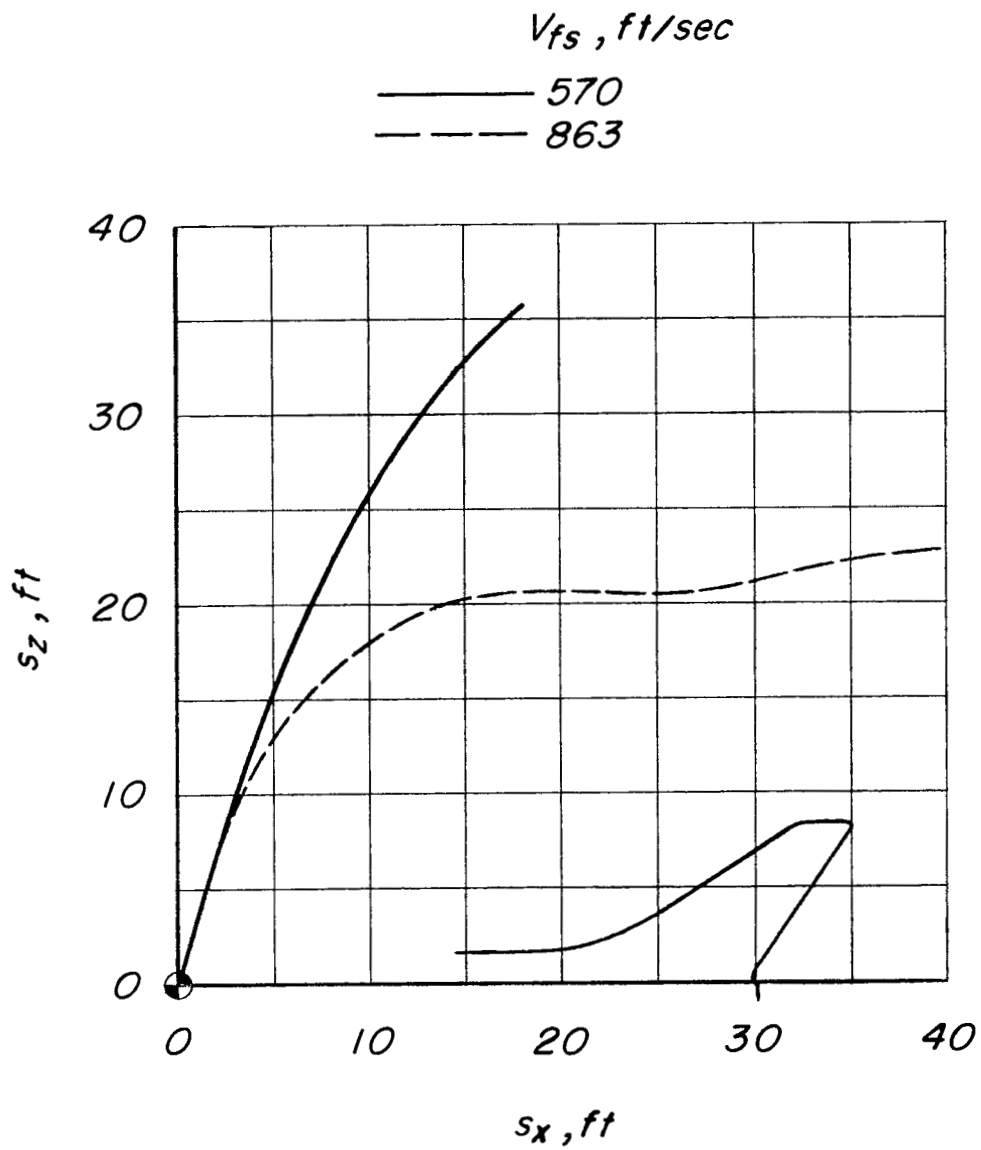


Figure 7.- Variation of vertical displacement with horizontal displacement.

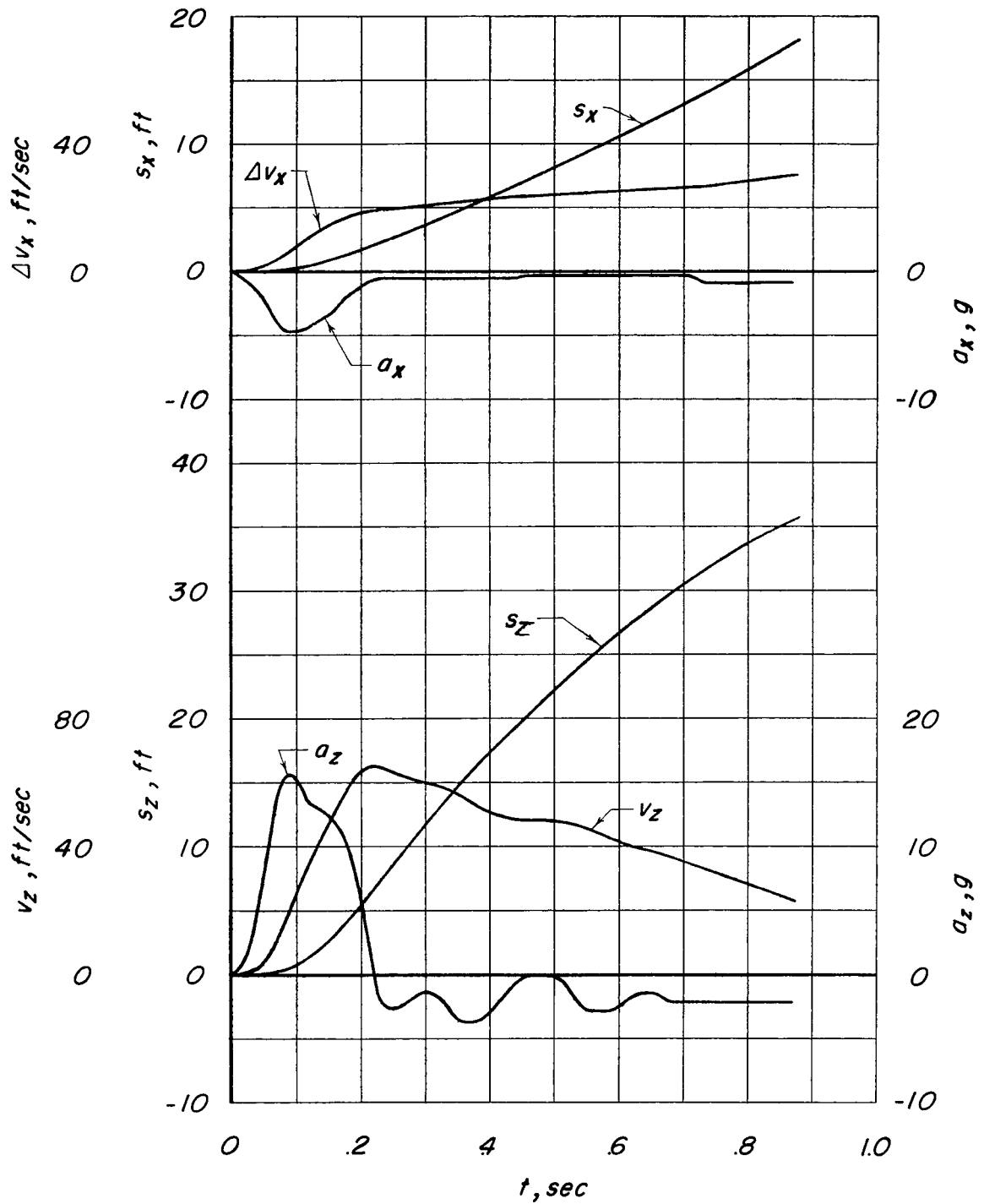


Figure 8.- Variation of displacements, velocities, and accelerations with time. $V_{fs} = 570 \text{ ft/sec}$ (389 mph).



L-74066

Figure 9.- Motion and path of the model escape capsule following ejection.
 $V_{fs} = 863 \text{ ft/sec (588 mph)}$.

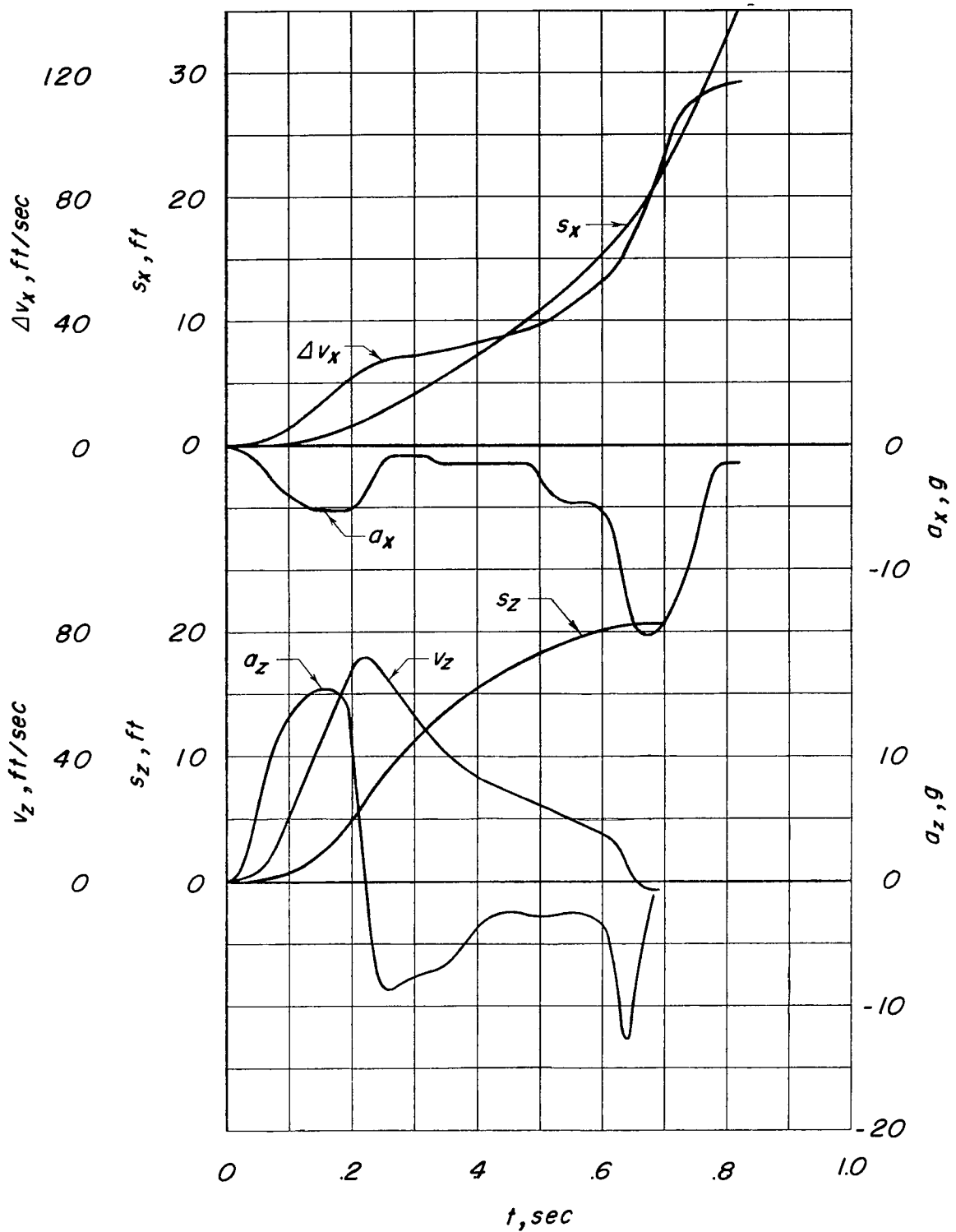


Figure 10.- Variation of displacements, velocities, and accelerations with time. $V_{fs} = 863 \text{ ft/sec}$ (588 mph).

SECU

NASA Technical Library



3 1176 01438 6651

MATION

